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POTENTIAL NEW USES FOR ANIMAL FATS

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Inedible animal fats are the raw materials for industries of substantial proportions; the annual consumption of these fats is about 2 billion pounds. About 80 to 85 per cent is used in the manufacture of soap; most of the remainder goes into fatty acid production (10 per cent), lubricants and greases (5 per cent), and the rest is used in many miscellaneous applications. The wide variety of these applications is illustrated by the following admittedly incomplete list of industrial uses for inedible animal fats.

Fields of Use for Animal Fats and their Derivatives

Fats	Glycerol	Fatty Acids
Cutting oils		Candles
Detergents		Carbon paper
Electrical insulation		Chemicals
Fatty acids		Coatings
Palmitic		Cosmetics
Stearic		Detergents
Oleic		Drugs
Fuel		Emulsifiers
Glycerol	plastics	Fungicides
Greases	foods	Greases
Leather	explosives	Heavy metal salts
Illuminants	drugs	Insecticides
Lubricants	cosmetics	Intermediates
Metal working		Lubricants
Oxidized oils		Metal working
Paints		Mold release agents
Plasticizers		Ointments
Printing inks		Ore flotation agents
Protective coatings		Points
Roofing		Plastics
Rubber		Plasticizers
Soap		Rubber
Textiles		Shaving cream
Varnishes		Soap
Waterproofing		Textiles
		Varnishes
		Waterproofing
		Waxes

In spite of the many uses for inedible animal fats, except during periods of unusually high industrial activity, new and expanded uses are urgently needed to keep the industry healthy. Important reasons for this are:

(1) Production of by-product animal fat is increasing as a direct result of increased consumption of meat by the American people

(2) Materials traditionally obtained from fats are meeting increasing competition in use from products from non-fat sources

(3) Research in the development of new and expanded industrial uses for inedible animal fats has not been conducted on the same scale as similar research on petroleum and coal tar, and therefore has not been able to keep pace with them.

To promote the healthy growth desired, it is to be hoped that the inedible animal fat industry may enter an era of research and development comparable to periods already passed through by the petroleum and coal tar industries. These periods are all characterized by the development of many new products and by a marked trend toward the production of chemically homogeneous substances. To provide most effective aid to the inedible animal fat industry, such research and development must be directed toward expanding portions of our economy.

Perhaps the greatest increase in industrial consumption of animal fats will be made possible by improving present products to meet expanding and diverse needs. This process is already under way in the field of soap and synthetic detergents. The development of a special soap essentially free of polyunsaturated constituents for use as an emulsifier in synthetic rubber manufacture is an example of such improvement (1). There seems to be little doubt that this development served to retain a substantial portion of this market for tallow, and at the same time resulted in improved products and important economies for the rubber industry.

In a similar manner, it is probable that investigations of the detailed requirements in other fields of soap application could prevent their replacement by synthetics to some extent. At the same time, it seems reasonably sure that certain fundamental characteristics of soap, such as insolubility of the calcium salts, cause it to be in a vulnerable position in many of the ordinary uses. This brings us to a consideration of the possibilities inherent in the animal fats and their derivatives as a source of synthetic detergents, emulsifiers, and other surface-active agents. It is known that products having many desirable detergent characteristics can be prepared, and some progress has been made in the commercial production of several. It is too early to state whether all the problems of producing a competitive general purpose detergent including costs, can be overcome, but certainly the effort should be commensurate with the potential rewards.

By analogy with petroleum and coal tar, it seems probable that considerable increase in industrial consumption of animal fats may also come by way of purified fatty acids and their derivatives. Again it is possible to cite some evidence of progress along these lines. For the past decade or so, saturated fatty acids and derivatives of high purity (90 per cent) have been available for research and industrial use at moderate prices. Although this has undoubtedly stimulated new uses, the chemist's concept of functionality indicates that the production of the unsaturated components of fats in an industrially pure form may be even more attractive.

Ordinary oleic acid of commerce, usually called red oil, is a light-yellow to dark-brown liquid, which contains 65-75 per cent oleic acid; the remainder is saturated and polyunsaturated acids in approximately equal amounts. As a result of its heterogeneous and variable composition, many efforts to develop new uses for it particularly in the chemical field have been disappointing. Its poor color- and odor-stability and the ease with which it forms gummy polymerization and oxidation products are serious disadvantages in many of its industrial uses.

The first commercially feasible procedure for the preparation of a purified grade of oleic acid (monoethenoic acid content, 85-98 per cent) was described in 1944 by research workers at the Eastern Regional Research Laboratory (2). In 1946 this group developed (3) an improved procedure which converted most of the polyunsaturated acids to monounsaturated acids by selective hydrogenation. After hydrolysis of the selectively hydrogenated fat, a fatty acid mixture consisting mainly of saturated and monounsaturated acids is obtained. By solvent crystallization of the mixed acids at temperatures from about 0^{o} to -20^{o} centigrade – temperatures well within the operating range of present-day commercial practice – the solid acids precipitate and are separated by filtration. These solid acids, which correspond approximately to double pressed stearic acid, are obtained in high yield. Recovery of the solvent from the filtrate yields a residue consisting of about 90 per cent oleic acid, 1-3% polyunsaturated acids and the remainder saturated acids. By fractional distillation, the oleic acid content can be increased to even higher levels. Somewhat later a process was described by Goebel of Emery Industries, Inc. (4) in which the polyunsaturated acids were selectively removed by thermal polymerization. Over-all considerations indicate that either process is capable of producing a purified oleic acid costing only slightly more than red oil. Hence, it is not surprising that in 1949 an improved oleic acid was made commercially available by a large producer of fatty acids.

Purified oleic acid can be used wherever good color- and odor-stability and high resistance to oxidation and polymerization are required, and as a chemical intermediate. Red oil is not a good chemical intermediate because the impurities, notably polyunsaturated acids, cause reactions to proceed inefficiently and result in low yields of desired products. Purified oleic acid is a much better intermediate both from the chemical and the dollars and cents standpoints.

Oleic acid is of great interest as a chemical intermediate because it contains two reactive functional groups, the ethylenic group and the carboxyl group. Reaction of the ethylenic group of oleic acid yields numerous products of actual and potential value, such as mono- and dihydroxystearic acids, epoxystearic acids, arylstearic acids, and mono- and dibasic acids, which are formed by cleavage with oxygen or other oxidizing agents. The hydroxy and epoxy acids are potentially useful in the preparation of waxes, plasticizers and wetting agents.

Reaction of the carboxyl group of oleic acid yields a wide variety of amides, salts (soaps) and esters. Amides of oleic acid can be readily converted to products with useful wetting, detergent and waterproofing properties merely by the proper choice of reactions. Water-insoluble soaps of oleic acid are useful as oxidation catalysts and in the preparation of greases. The synthetic ester, glyceryl trioleate, prepared from purified oleic acid and glycerol, shows promise as an inedible olive oil substitute. Esters of oleic acid and its ethylenic derivatives are used commercially as textile processing aids and as plasticizers. Unfortunately, the ordinary alkyl esters of fatty acids do not have all the properties which would make them entirely acceptable as plasticizers in those plastics which have found widest commercial acceptance. Several approaches to the problem of increased utilization of fats in plasticizers are being explored. These include modification of the fatty acid before esterification (5) and preparation of esters having complex alcohol groups (6).

A different approach to the use of fat derivatives in plastics is being investigated at the Eastern Regional Laboratory (7). Alkenyl esters, principally the vinyl esters and others of oleic and the saturated acids are being studied for use as comonomers in the preparation of vinyl type plastics. Although it is too early to predict specific fields of use, internally plasticized polymers having a wide range of properties can be prepared in this way. Such products are not only free of the numerous generic defects which arise from plasticizer migration, but also offer some hope that if further plasticization is required the cheaper fatty derivatives might be more successfully used.

Still another type of plasticizer or plastic modifier may be prepared by condensation of hydroxy acids, with themselves or with modifying materials.

It seems probable that the greatest use of fats and fat derivatives in plastics and allied fields would follow closely on the heels of development of a completely satisfactory process for preparing dibasic acids from fats. Most processes now in use or proposed require expensive and corrosive oxidizing agents, but a really satisfactory and economical process for preparing dibasic acids could easily result in utilization of millions of pounds of fats per year.

Dibasic acids such as azelaic acid are not only valuable in the preparation of polyester resins but according to Zisman and coworkers (8) serve as a basis for synthesizing excellent grease and lubricating oils. Contemplation of the potential markets in these fields suggests that research along these lines should be exceptionally rewarding.

The field of additives to lubricants is also an actively growing one in which fats and their derivatives offer considerable promise. Lubricants being marketed frequently contain 5 to 10 per cent additive or even more. A list of purposes for which additives are used indicates the potential value of fats if the proper derivatives are found. These include: accentuation of "oiliness", modification of viscosity, improvement of viscosity index, detergents, lowering of "pour point", inhibition of corrosion, inhibition of oxidation All of these except the last might be met by fat derivatives,

Derivatives and products from animal fats have long been used in the preparation of greases and special lubricating products. Increasing demands for such lubricants by both military and civilian users require and also encourage the development and production of improved fat products for this use. Hydroxy acids offer special promise in this field.

Although research performed on the purest possible derivatives is usually more informative than that done on complex mixtures, many potential uses exist for improved materials which are by no means pure chemicals. At present the only glyceride fractions manufactured from animal fats are stearin and lard oil. The inherent possibilities in glyceride fractions seem to await further development, although the technical information is largely available for making such fractions or for preparing products having improved properties by starting with specially processed materials such as a selectively hydrogenated fat.

It is impossible in a paper of this length to discuss all the potential new uses for animal fats in detail. No detailed reference has been made to use of the edible meat fats in new and improved food products, despite enormous possibilities for a roll-back of the competition in this field. In the inedible field uses for such important classes of compounds as hydroxy compounds, ethers, epoxides, peroxides and nitrogen derivatives have been barely mentioned.

We can only hope that the things we have mentioned will serve as catalysts to the imagination of others and thus promote the development of new products and the trend toward the production of chemically homogeneous substances. In this way we are most certain to broaden the utilization base for this important food and industrial raw material, the animal fats.

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